QUANTIFYING THE EFFECTS OF WATER DEFICIT STRESS ALLEVIATION IN DIFFERENT PHENOLOGICAL STAGES OF THE COTTON PLANT AND ITS IMPACT ON GROWTH AND YIELD

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Abstract

In order to be high yielding, the cotton plant must develop a vegetative framework big enough to allow the development and growth of fruits. Under water deficit conditions, the cotton plant faces restrictions on its vegetative and reproductive development, which, ultimately, leads to lower yields. Water deficit stress alleviation, either by rainfall or supplemental irrigation, will enable plants to grow and retain more fruiting sites. This paper describes a study designed to determine the effect of supplemental irrigation at different phenological stages in cotton. Results showed that supplemental irrigation increased whole-plant transpiration irrespective of phenological timing, but increased total dry biomass only when applied from MH to 1B and from 1B to MB. These effects did not impact significantly yield or WUE.

Introduction

Knowing the impact of soil water availability on the ability of the plant to initiate, retain, and mature harvestable bolls is of most importance for optimizing water management decisions in cotton crops (Hake and Grimes, 2010). Plant water deficits induced by low available soil water and/or high evaporative demand reduce the total number of potential fruiting points as a result of a general reduction in shoot growth (Jordan, 1986). Quantification of the water deficit stress alleviation in different phenological stages would be useful to determine the efficacy of limited supplemental irrigation. This paper presents results from an experiment designed to assess the effects of one-short irrigation at different phenological stages on growth and yield of moderately water-stressed cotton grown under controlled rain-sheltered conditions.

Materials and Methods

The study was conducted in 2014 at the Drought Tolerance Lab in the AgriLife Research and Extension Center at Corpus Christi. Cultivar PHY375 was planted on April 2nd, in 3.6-gallon pots filled with fritted clay soil. The experimental set up consisted of a complete randomized design with 4 treatments (Table 1) and 4 reps.

Table 1. Treatments description.

Treatment	Irrigation/stress schedule
1	Control (moderately stressed throughout the study) – 1.0 L/day
2	Fully irrigated from Match Head (MH) to 1st Bloom (1B) – 2.4 L/day
3	Fully irrigated from 1st Bloom (1B) to Mid Bloom (MB) – 2.4 L/day
4	Fully irrigated from MB to 1st Cracked Boll (CB) - 2.4L/day

All pots were irrigated with 0.8 L/day until MH, May 07, when the treatments were applied. Plants went back to stress (1 L/day) after the irrigation treatments were finished. Transpiration was measured continuously using electronic weighing mini-lysimeters. Plants were harvest on August 14 for measuring growth and yield parameters. The data were analyzed by ANOVA, and means separated by Fisher's LSD at $\alpha = 5\%$ using SAS.

Results and Discussion

Daily transpiration data for the control and irrigation treatments (L/day) are shown in Fig. 1. After irrigation was imposed, treatment 2 increased transpiration rates up to 1.5 L/day, treatment 3 up to 2 L/day, and treatment 4 up to 1.8 L/day.

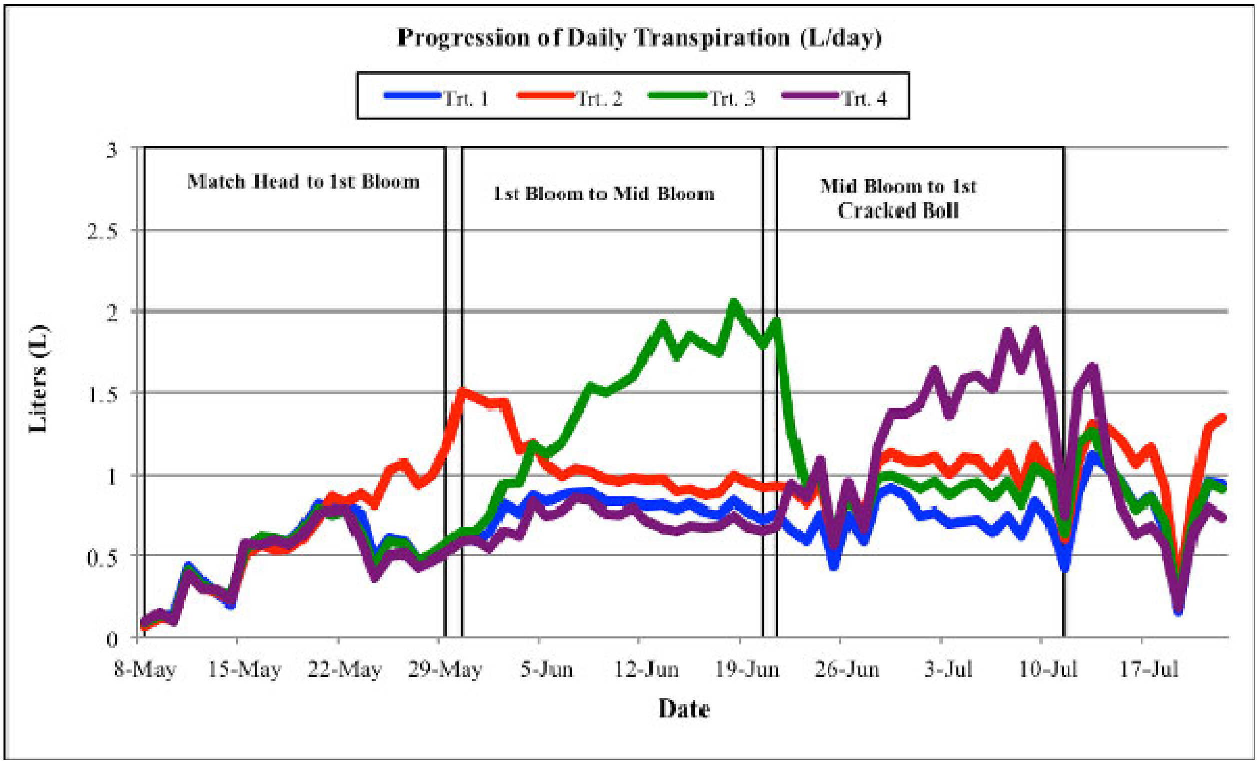

Figure 1. Average daily transpiration (L/day) data for the 4 treatments during the season.

Cumulative transpiration values per growth stage and throughout the season are shown in Table 2. Supplemental irrigations significantly increased transpiration at each phenological stage and this effect was also reflected on the total cumulative transpiration at the end of the study. Throughout the season, the control treatment transpired significantly less than other treatments.

Table 2. Cumulative transpiration (L) per stage and total transpiration (L) for the 4 treatments.

Treatments	**Cumulative transpiration (L)**			
	Match Head to 1st Bloom	**1st Bloom to Mid Bloom**	**Mid Bloom to 1st Cracked Boll**	**Total**
1	10.9 b	17.3 c	14.7 c	51.9 c
2	13.5 a	23.5 b	20.3 b	69.0 ab
3	10.8 b	31.5 a	20.2 b	72.1 a
4	10.2 b	15.5 c	26.4 a	61.5 b

Means with different letters are significantly different at the 5% probability level.

Supplemental irrigations significantly increased plant leaf area when applied before the MB stage (Fig. 2 and Table 3). At 1B, plant leaf area (LA) in treatment 2 was significantly higher than the control and the other treatments. At MB, LA in treatment 3 was significantly higher than all other treatments, while treatment 2 remained higher than the control and treatment 4. At 1CB, there were no significant differences among treatments.

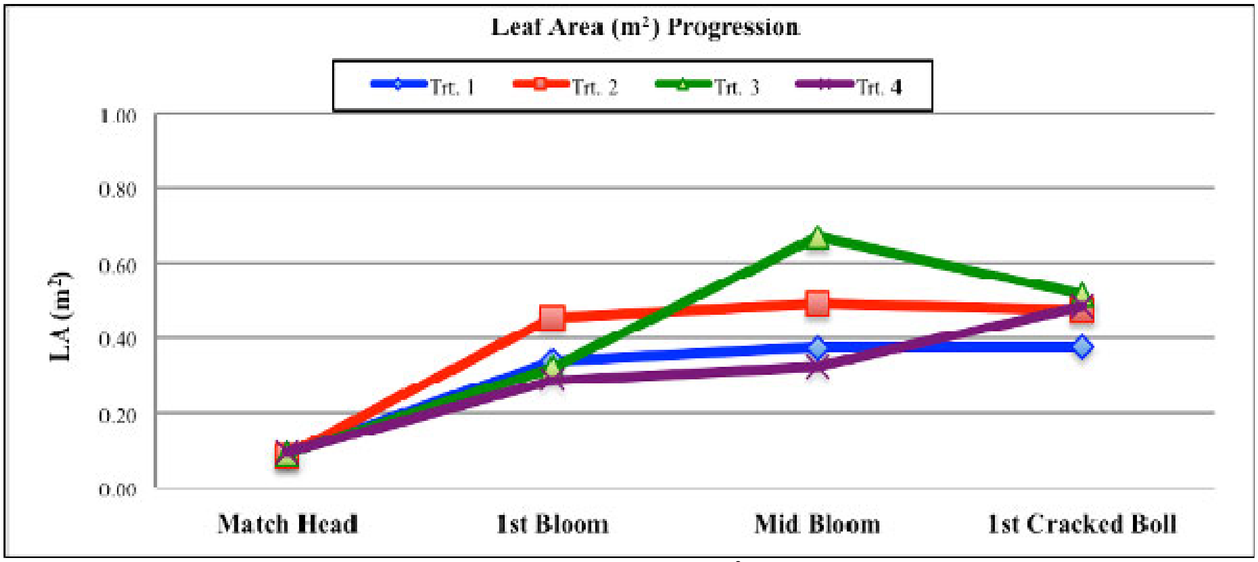

Figure 2. Progression of plant leaf area (m^2) for the 4 treatments.

Table 3. Leaf Area (m^2) at 4 different stages for the 4 treatments.

Treatments	Leaf Area (m^2)			
	Match Head	1st Bloom	Mid Bloom	1st Cracked Boll
1	0.09 a	0.34 b	0.37 c	0.38 a
2	0.09 a	0.46 a	0.49 b	0.48 a
3	0.09 a	0.32 b	0.67 a	0.53 a
4	0.09 a	0.29 b	0.33 c	0.49 a

Means with different letters are significantly different at the 5% probability level.

Supplemental irrigation from MH to 1B and from 1B to MB, both significantly increased total dry matter (sum of all plant parts including seedcotton) at the end of the season (Table 4).

Supplemental irrigation increased the number of reproductive sites regardless of phenological stage timing, but bolls/plant and fruit retention were not significant among treatments (Table 4). That might explain the fact that seedcotton and lint per plant were not significant among treatments.

WUE total (total drymatter yield/total transpiration) was significantly higher in treatment 2 than in 4 but not different from the control or treatment 3. WUEeconomic (seedcotton/total transpiration) and WUElint (lint/total transpiration) did not show significant differences (Table 5).

Table 4. Mean values of total dry matter yield; yield components, and plant mapping for the 4 treatments.

Trts.	Total Dry Matter Yield/Plant	Seedcotton /Plant	Lint/Plant	Avg. N° of reproductive sites/Plant	Avg. N° of Bolls/Plant	Avg. Boll Retention/Plant
	g	*g*	*g*			%
1	183.0 b	59.0 a	23.7 a	34 b	16 a	47 a
2	253.8 a	66.9 a	29.7 a	54 a	24 a	44 a
3	249.5 a	76.2 a	30.7 a	51 a	24 a	47 a
4	201.6 b	59.1 a	23.7 a	45 a	21 a	48 a

Means with different letters are significantly different at the 5% probability level.

Table 5. Mean values of water use efficiency for the 4 treatments.

Trts.	WUE total	WUE economic	WUE lint
	g/L	*g/L*	*g/L*
1	3.53 ab	1.13 a	0.49 a
2	3.68 a	0.97 a	0.43 a
3	3.46 ab	1.05 a	0.42 a
4	3.27 b	0.96 a	0.38 a

Means with different letters are significantly different at the 5% probability level.

Conclusions

Supplemental irrigation increased whole-plant transpiration irrespective of phenological timing, but increased total dry biomass only when applied from MH to 1B and from 1B to MD. But these effects did not impact significantly yield or WUE.

References

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